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Sleep deprivation and adolescent susceptibility to vaping in the United States

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ABSTRACT

Sleep deprivation may be a contributing factor to adolescents' willingness to experiment with substance use, including electronic nicotine devices (ENDS). While it is generally accepted that nicotine has a negative overall effect on sleep, no studies have yet explored whether sleep deprivation may contribute to adolescents' initiation of ENDS use. The purpose of this study is to explore whether sleep deprivation is associated with adolescents' self-reported susceptibility to initiating ENDS use in the next month. Respondents were 1,100 adolescents aged 13–17 across the United States who participated in the Vaping Attitudes Youth Perspectives Survey (VAYPS). We used logistic regression to examine cross-sectional associations between self-reported average sleep duration and self-reported likelihood of trying ENDS in the future. Results of the three logistic regression models show that adolescents who reported getting less than six hours of sleep per night were associated with greater odds of reporting any likelihood to try a vape in the next 30 days even when controlling for demographics and potential confounders (<6hrs sleep: OR = 2.63, 95% CI 1.30–5.31). Future research on the association between sleep deprivation and ENDS use among adolescents will benefit from using longitudinal approaches to better understand causality.

1. Introduction

Adolescent use of electronic nicotine delivery systems (ENDS), also known as e-cigarettes or vapes, is a pressing public health concern. Increasing evidence continues to suggest that ENDS use, typically referred to as vaping, produces potentially long-term, substantial, negative health and behavioral consequences (Tobore, 2019; Jones & Salzman, 2020). Sleep deprivation is one emerging negative health association linked to adolescent ENDS use; however, the directionality of this association has yet to be fully explored.

The National Sleep Foundation considers eight to ten hours of sleep appropriate for adolescents' emotional, cognitive, and physical health (Hirshkowitz et al., 2015). Indeed, many adolescents fall short of this threshold, resulting in potentially serious detriments (Short and Louca, 2015; Short et al., 2018). Previous research on sleep deprivation among adolescents has unveiled a multitude of unhealthy correlates including, mental health struggles (Jamieson et al., 2020), mood deficits (Short and Louca, 2015), substance use (Wong et al., 2010), higher risk-taking behaviors (Telzer et al., 2013), delinquency (Clinkinbeard et al., 2011), long-term damage to the brain (Durmer & Dinges, 2005), and even suicidal ideation (Goldstein et al., 2008; Riehm et al., 2019).

The majority of ENDS contain nicotine, research shows that the average level of nicotine found in ENDS increased by over 100% in the United States from 2013 to 2018 (Romberg et al., 2019). The addictive nature of nicotine is well established, and higher doses of nicotine are related to higher likelihoods of experiencing addiction and withdrawal symptoms (Benowitz & Henningfield, 1994). Previous studies assessing the effects of stimulatory reactions to nicotine on sleep support the assumption that ENDS use contributes to sleep deprivation (Wiener et al., 2020; Mathews & Stitzel, 2019). However, few studies have examined the association between ENDS use and sleep deprivation, and even fewer have studied the association among adolescents. Riehm et al. (2019) were among the first to confirm a significant association between vape use and sleep related-complaints among adolescents by comparing ENDS-only users and cigarette-only users to those who never used ENDS or cigarettes.

While studies have found similar associations between lack of sleep and ENDS use among adolescents (Brett et al., 2020; Riehm et al., 2019, Kianersi et al., 2021), the directionality of this association has yet to be clearly established. Abounding evidence suggests that nicotine, as a

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stimulant, negatively affects sleep (Wiener et al., 2020; Mathews & Stitzel, 2019); however, lack of sleep may also affect the likelihood that someone initiates ENDS use in the first place (Wiener et al., 2020).

Kianersi et al. (2021) estimated that former ENDS users were 1.17 times more likely to experience sleep deprivation than those who had never used; this ratio increased to 1.42 when comparing everyday ENDS users to those who never used ENDS. The finding that former ENDS users were likely to experience sleep deprivation is particularly interesting as it challenges previous ideas of stimulation or addiction withdrawal as the key mechanisms by which nicotine use relates to sleep deprivation. Is it nicotine use itself or another related variable that is responsible for sleep deprivation?

Previous studies on adolescent ENDS use and sleeping behaviors have compared people who use ENDS to those that do not use or have used in the past. To date, we have not seen studies that have assessed whether adolescents who have never used ENDS but are susceptible to future use vary in sleep behaviors from those not susceptible.

1.1. Study objectives

The main objective of this study is to assess whether sleep deprivation is associated with adolescent susceptibility to initiate ENDS use. As mentioned above, sleep deprivation may have lasting detrimental impacts on the adolescent brain which may lead to lower cognitive functioning, higher risk-seeking behaviors, and overall impaired inhibitory control. Furthermore, longitudinal analysis has shown that sleep problems in early childhood are associated with later substance use including cigarettes in adolescence (Wong et al., 2010). For these reasons, we hypothesized that sleep deprivation would be associated with adolescent self-reported susceptibility to initiate ENDS use. In this study, we explore the association between ENDS susceptibility and sleep deprivation while controlling for potential confounders previously found to be associated with higher degrees of ENDS use and susceptibility.

Weaver et al. (2018) compared a multitude of risk-taking outcomes including adolescent tobacco use and average sleep durations reported by adolescents. They found the largest differences in risk-taking behaviors occurred between adolescents who received eight or more hours of sleep and adolescents who received less than six hours. Thus, for this study we use the same thresholds to explore differences in susceptibility to ENDS use. Because previous literature suggests that risk-taking (Carey et al., 2019), exposure to peer use (Mantey et al., 2021), perceived enforcement of parental rules (Wu & Chaffee, 2020), and school rules against vaping (Milicic et al., 2018) may contribute to the likelihood that adolescents will experiment with ENDS, we controlled for these potential confounders in our analyses.

2. Methods

2.1. Study design

We used cross-sectional data from our Vaping Attitudes Youth Perspectives Survey (VAYPS) (Holtz et al., 2022) to compare average reported hours of sleep between varying levels of ENDS susceptibility among respondents in our sample who reported never having used ENDS previously. This study was approved by KDH Research and Communication (KDHRC) internal IRB, FWA00011177, IRB 00005850.

2.2. Sample and survey

In May of 2020, we contracted the research firm, Marketing Workshop (MW) to recruit and administer a one-time, online survey to adolescents, aged 13 to 17, across the United States. MW and their panel partner Market Cube (MC) recruited adolescent respondents and managed all data collected on https://www.confirmit.com between June 2, 2020 and June 11, 2020. To achieve evenly distributed responses, MW's panel partner stopped inviting new respondents once target quotas were met.

To recruit youth, MC distributed invitations to randomly selected panel members (e.g., parents of eligible youth) on a rolling basis. Upon enrollment into MC's research panel, potential members provided information, including demographics, household composition, lifestyle elements, and health profiles. Upon the study's launch, MC sent out 8,500 email invitations to parents on the panel with youth in the target age range (13–17). The initial email included an invitation to have their youth participate in a new survey. The email invitation also included a link that detailed the purpose of the study. After reading this invitation, the parent had two options:.

1. If the parent determined that they would like their youth to participate in this particular survey, they were asked to forward the study link to their youth, thereby actively opting in and providing permission for their youth to participate in the study. Youth accessed the study link included in the email forwarded by their parents that detailed the purpose of the study and included study materials. Youth were directed to review the purpose of the study and complete the screener and assent form. If youth provided assent, the youth went directly into the survey and were able to complete it the survey from the comfort of their current location.
2. If the parent did nothing, the invitation died in place and that parent's child never received information about the study.

If a parent consented but their child did not respond to the survey, MC did not send reminders and considered the youth null. However, youth could return and complete the survey at a later time. Respondents received a modest incentive in the panel company's points award system from which they were recruited, the incentive amount was customarily determined by the partner and the award system was distributed in a manner agreed upon when respondents opted-in to the panel. The amount of the incentive depended on the status of established quotas and the extent to which respondents completed the survey. A higher amount of points were awarded to respondents who completed all survey questions.

Eligibility criteria for the survey was limited to age only. The full sample consisted of 1,100 adolescent respondents who fully answered the survey. For the purposes of this study, eligibility included the 795 respondents who reported never having used ENDS before and who answered questions regarding likelihood to use ENDS in the future. The survey consisted of 181 questions on ENDS-related attitudes and behaviors and explored demographic, psychographic, social, and behavioral variables of interest.

2.3. Measures

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2.4. Covariates

Below we provide operational definitions for each.

Age: The age of the respondent when answering the VAYPS survey ranged from 12 to 17.

Gender: A dummy variable was created where 1 represented "female" and 0 represented "male" as the reference.

Race: Dummy variables were created for each race ("White," "Native Alaskan/American Indian," "Asian," "Black," "Pacific Islander," "Mixed Race," and "Other"). "White" was used as the reference.

Ethnicity: A dummy variable was created where 1 represented "Hispanic ethnicity" and 0 represented "non-Hispanic ethnicity" as the reference.

Risk-taking: Respondents were asked, "How much of a risk taker are you?" Answer choices were an 11-point subjective scale ranging from 0 to 10, where 0 represented "not a risk taker at all," 5 represented "neutral," and 10 represented "very much a risk taker.".

Have close friends that vape: Respondents were asked, "Have any of your five closest friends vaped (even just one puff)?" For this dummy variable, 1 represents respondents who answered "yes" and 0 represents respondents who answered "no" as the reference.

Parental enforcement: Respondents were asked, "To what extent are your parents likely to enforce their rule or rules against vaping?" Answer choices were an 11-point subjective scale ranging from 0 to 10, where 0 represented "extremely unlikely," 5 represented "neutral," and 10 represented "extremely likely.".

School enforcement: Respondents were asked, "To what extent is your school likely to enforce their rule or rules against vaping?" Answer choices were an 11-point subjective scale ranging from 0 to 10, where 0 represented "extremely unlikely," 5 represented "neutral," and 10 represented "extremely likely.".

2.5. Independent variable

Sleep deprivation: Respondents were asked, "Over the past week, roughly how many hours did you sleep per night?" Answer choices included, "<2 h," "three to five hours," "six to eight hours," and "more than eight hours." A dummy variable was created where 1 represented a respondent who reported getting less than six hours of sleep per night and 0 represented a respondent who reported getting at least six or more hours of sleep per night as the reference.

2.6. Dependent variable

We asked all respondents, "Have you ever vaped (even just one puff)?" We then asked adolescents who reported never having vaped before, "How likely are you to try a vape in the next month?" Answer choices were an 11-point subjective scale ranging from 0 to 10, where 0 represented "extremely unlikely," 5 represented "neutral," and 10 represented "extremely likely." Nearly 86% of surveyed adolescents answered 0, skewing the variable strongly right. We transformed these answers into a dummy variable where 1 represented any reported likelihood (1–10) and 0 represented respondents who reported 0 (extremely unlikely) as the reference.

2.7. Analyses

Analyses were conducted on Stata IC, version 16.1. We used chi-square tests for categorical variables and pairwise t-tests for continuous variables to compare respondents' characteristics between adolescents who reported any likelihood of initiating ENDS use in the next month to respondents who reported zero likelihood of initiating ENDS use in the next month. Missing data and questions answered with "prefer not to answer" were excluded from analyses. We used multivariate logistic regression models to estimate the adjusted odds ratios and 95% confidence intervals of sleep deprivation on the reported likelihood of initiating ENDS use in the next 30 days. We compared three models. Model 1 was an unadjusted model. Model 2 was adjusted for respondent demographics including age, gender, race, and ethnicity. Model 3 was adjusted further to include demographics and potentially confounding factors including risk-taking, having close friends who use ENDS, parental enforcement, and school enforcement. Statistical significance was set at $p \leq 0.05$.

3. Results

3.1. Respondent characteristics

Table 1 presents respondents' characteristics overall and according to reported likelihood of initiating ENDS use in the next 30 days. Our full sample (n = 1100) achieved an equal mix of ages 13–17 and gender. Percentages of race closely mirrored national averages among this age range and the majority were non-Hispanic (86.8%). Among the 800

Table 1
Sample characteristics and variable distributions.

Sample characteristics	Total sample (n = 1100)	Never used ENDS (n = 800)	Non-susceptible (n = 682)	Susceptible (n = 113)	p-value
Age, years (mean sd)	15 (1.41)	14.87 (1.41)	14.88 (1.39)	14.79 (1.54)	0.53
Age, years					
13	220 (20%)	181 (23%)	148 (22%)	32 (28%)	**0.04**
14	220 (20%)	171 (21%)	145 (21%)	26 (23%)	
15	220 (20%)	159 (20%)	142 (21%)	15 (13%)	
16	220 (20%)	152 (19%)	136 (20%)	14 (12%)	
17	220 (20%)	137 (17%)	111 (16%)	26 (23%)	
Gender					**0.04**
Female	550 (50%)	413 (52%)	363 (53%)	47 (42%)	
Male	535 (49%)	378 (47%)	313 (46%)	64 (57%)	
Other	7 (1%)	5 (1%)	3 (0%)	2 (2%)	
Prefer not answer	8 (1%)	4 (1%)	3 (0%)	0 (0%)	
Race					0.69
Native	12 (1%)	8 (1%)	7 (1%)	1 (1%)	
White	755 (71%)	529 (66%)	446 (65%)	79 (70%)	
Asian	78 (7%)	67 (8%)	55 (8%)	12 (11%)	
Black	124 (12%)	101 (13%)	88 (13%)	12 (11%)	
Pacific	4 (0%)	3 (0%)	3 (0%)	0 (0%)	
Islander Mixed race	50 (5%)	39 (5%)	37 (5%)	2 (2%)	
Other race	45 (4%)	33 (4%)	29 (4%)	4 (4%)	
Prefer not to answer	32 (3%)	20 (3%)	17 (2%)	3 (3%)	
Ethnicity					0.47
Hispanic	143 (13%)	101 (13%)	89 (13%)	12 (11%)	
Not Hispanic	943 (87%)	690 (86%)	586 (86%)	100 (88%)	
Prefer not to answer	14 (1%)	8 (1%)	7 (1%)	1 (1%)	
Sleep					
< 6 h	133 (12%)	80 (10%)	59 (9%)	19 (17%)	**<0.01**
≥ 6 h	955 (88%)	715 (90%)	619 (91%)	94 (83%)	
Prefer not to answer	12 (1%)	5 (1%)	4 (1%)	0 (0%)	
Risk-taking					**<0.01**
0	66 (6%)	60 (8%)	58 (9%)	2 (2%)	
1	23 (2%)	20 (3%)	18 (3%)	1 (1%)	
2	68 (6%)	58 (7%)	52 (8%)	6 (5%)	
3	81 (7%)	68 (9%)	59 (9%)	9 (8%)	
4	97 (9%)	87 (11%)	74 (11%)	13 (12%)	
5	226 (21%)	170 (21%)	155 (23%)	15 (13%)	
6	147 (13%)	108 (14%)	88 (13%)	19 (17%)	
7	141 (13%)	89 (11%)	73 (10%)	15 (13%)	
8	114 (10%)	74 (9%)	59 (9%)	15 (13%)	
9	48 (4%)	30 (4%)	20 (3%)	10 (9%)	
10	71 (6%)	28 (4%)	20 (3%)	7 (6%)	
Prefer not to answer	18 (2%)	8 (1%)	6 (1%)	1 (1%)	
Close friends vape					**<0.001**
Yes			175 (26%)	61 (54%)	

(continued on next page)

Table 1 (*continued*)

Sample characteristics	Total sample (n = 1100)	Never used ENDS (n = 800)	Non-susceptible (n = 682)	Susceptible (n = 113)	p-value
	510 (46%)	237 (30%)			
No	561 (51%)	544 (68%)	495 (73%)	47 (42%)	
Prefer not to answer	29 (3%)	19 (2%)	12 (2%)	5 (4%)	
Parental enforcement					**<0.001**
0	35 (3%)	20 (3%)	18 (3%)	2 (2%)	
1	4 (0%)	3 (0%)	3 (0%)	0 (0%)	
2	12 (1%)	3 (0%)	2 (0%)	1 (1%)	
3	13 (1%)	6 (1%)	3 (0%)	3 (3%)	
4	10	4 (1%)	2 (0%)	2 (2%)	
5	(0.91%) 116 (11%)	74 (9%)	58 (9%)	16 (14%)	
6	35 (3%)	21 (3%)	10 (1%)	11 (10%)	
7	71 (6%)	42 (5%)	33 (5%)	9 (8%)	
8	86 (8%)	51 (6%)	33 (5%)	17 (15%)	
9	81 (7%)	51 (6%)	40 (6%)	11 (10%)	
10	602 (55%)	501 (62%)	460 (67%)	39 (35%)	
Prefer not to answer	35 (3%)	24 (3%)	20 (3%)	2 (2%)	
School enforcement					**<0.01**
0	18 (2%)	14 (2%)	12 (2%)	2 (2%)	
1	2 (0%)	2 (0%)	2 (0%)	0 (0%)	
2	6 (1%)	4 (1%)	2 (0%)	2 (2%)	
3	14 (1%)	11 (1%)	10 (1%)	1 (1%)	
4	18 (2%)	9 (1%)	7 (1%)	2 (2%)	
5	94 (9%)	68 (9%)	56 (8%)	12 (11%)	
6	50 (5%)	39 (5%)	32 (5%)	7 (6%)	
7	77 (7%)	56 (7%)	45 (7%)	11 (10%)	
8	112 (10%)	77 (10%)	59 (9%)	17 (15%)	
9	93 (8%)	65 (8%)	49 (7%)	16 (14%)	
10	587 (53%)	439 (55%)	395 (58%)	41 (36%)	
Prefer not to answer	29 (3%)	16 (2%)	13 (2%)	2 (2%)	

[1]Reported as n (%) unless listed otherwise.
[2]Percentages have been rounded to the nearest whole number.

respondents who reported never having used ENDS before, 795 answered the question about likelihood of initiating ENDS use in the next month. The majority reported no likelihood of initiating ENDS in the next month and were deemed non-susceptible (n = 682, 85.8%), while (n = 113, 14.2%) self-reported any likelihood of initiating ENDS in the next month and were deemed susceptible.

There were significant differences between susceptible and non-susceptible youth in age groups, gender, sleep, risk-taking, having close friends who use ENDS, parental enforcement, and school enforcement.

Table 2 presents the results of the three logistic regression models performed to assess the association between averaging less than six hours of sleep per night the week prior to the survey and the self-reported likelihood of initiating ENDS use in the next month. In Model 1, respondents who reported getting less than six hours of sleep had a significantly higher likelihood of initiating ENDS use in the next month compared to respondents who reported getting more than 8 h of sleep per night (<6hrs sleep: OR = 2.12 95% CI = [1.2–3.7]). This association was upheld in Model 2 while controlling for age, race, gender, and ethnicity (<6hrs sleep: OR = 2.52, 95% CI 1.3–4.7). The association was also upheld in Model 3 after further adjustment for various potential confounders including risk-taking, having close friends who use ENDS, parental enforcement, and school enforcement (<6hrs sleep: OR = 2.63, 95% CI 1.3–5.3).

Table 2
Logistic regression analyses of the association between sleep deprivation and likelihood of initiating ENDS in the next month.

Self-reported average sleep duration	Over 6 h sleepOR (95% CI)	Under 6 h sleepOR (95% CI)
Model 1	1 (ref)	2.12 (1.210–3.715)
Model 2	1 (ref)	2.52 (1.342–4.738)
Model 3	1 (ref)	2.63 (1.298–5.314)

OR, odds ratio; CI, confidence interval.
Model 1: Crude model.
Model 2: Multivariate model adjusted for age, gender, race, and ethnicity.
Model 3: Multivariate model adjusted for age, gender, race, ethnicity, risk-taking, having close friends who use ENDS, parental enforcement, and school enforcement.

The significance of sleep deprivation remained consistent across all models; thus the results were not sensitive to changes in the variables included. We assessed multicollinearity via the variance inflation factor (VIF) which reveals how much of the coefficient estimate's variance is being inflated due to multicollinearity (Senaviratna and Cooray, 2019). VIF values for Model 3 were under 1.34 for each control variable with an overall mean of 1.12, showing modest yet acceptable collinearity among variables.

4. Discussion

We aimed to assess whether sleep deprivation among adolescents is associated with self-reported likelihood of initiating ENDS use. In a sample of 795 adolescents across the United States who had never used ENDS, we found that the odds of self-reporting any likelihood of using ENDS in the next month is larger among adolescents who reported averaging six or less hours of sleep per night during the week prior to taking the survey compared to adolescents who reported averaging eight or more hours of sleep. This association remained significant after adjusting for respondent demographics, perceptions of self as a risk taker, the presence of close friends who use ENDS, and perceived enforcement of rules against ENDS by parents and schools.

Our findings indicate that even before initiation of ENDS use, adolescents susceptible to future ENDS use tend to experience significantly fewer hours of sleep on average compared to adolescents who report no likelihood of initiating ENDS. This finding is intriguing because previous research suggests that sleep deprivation among adolescents may damage the part of the brain responsible for experiencing pleasure/reward, potentially leading to riskier behaviors in attempts to compensate for this loss in sensitivity (Holm, et al. 2009).

The mechanisms driving sleep deprivation among adolescents are likely diverse and abundant, especially for a population subgroup that requires more hours of sleep than adults to perform optimally. Barriers to healthy sleep among adolescents include internal thought processes such as catastrophizing thoughts about social interactions and school-related performance (Hiller et al. 2014); overall strong positive or negative emotional states (Gruber et al. 2017); environmental factors such as evening light and negative family environment (Bartel et al. 2015); and behaviors including prolonged violent video gaming (King et al. 2013), caffeine consumption, and phone and computer use (Bartel et al. 2015). Additionally, changes in puberty status occurring during adolescence may affect sleep durations differently by age and gender (Knutson, 2005; Pesonen et al., 2014).

Sleep hygiene classes developed specifically for adolescents aim to address such barriers to healthy sleep and have been shown to enhance healthy sleep practices, reduce internalizing behavioral problems, and sustain overall performance at school (Wolfson et al. 2015). Studies have shown that cognitive behavioral therapy for insomnia among adolescents is effective in group or online settings (de Bruin et al., 2015). Such

interventions may eventually prove to not only support adolescents in getting healthy amounts of sleep but also help prevent adolescent initiation of ENDS use.

4.1. Study limitations

While we believe the findings in this study add important insights into the association of sleep deprivation and ENDS use, there are limitations. For one, we were limited in our ability to assess incremental differences in hours of sleep as we used ranges for categorical answer choices ("less than two hours," "three to five hours," "six to eight hours," and "more than eight hours)." Future research may benefit from write-in answers for similar questions rather than discrete categories which would allow further comparisons at each individual hour of reported sleep duration.

Furthermore, we used self-reported subjective feedback rather than actigraphy or polysomnography. Indeed, monitoring rest and activity may provide more precise feedback on sleep durations. Our study only asked about average duration of sleep per night during the week preceding the survey which may not represent longer-term sleep averages.

Another limitation in this study is that the questions asked in the VAYPS survey have not been previously validated; however, questions about use and susceptibility closely mirror components of the adapted Pierce measure. The adapted Pierce measure uses four questions on peer pressure and youth's curiosity around and intentions to use ENDS to predict overall susceptibility to initiating ENDS use. The questions include: *Have you ever been curious about using an electronic cigarette or e-cigarette, even once or twice? Do you think you will try an electronic cigarette or e-cigarette soon? Do you think you will use an e-cigarette in the next year?* and, *If one of your best friends were to offer you an electronic cigarette or e-cigarette, would you use it?* Answer choices are: "*Definitely yes,*" "*Probably yes,*" "*Probably not,*" and "*Definitely not.*" ENDS susceptibility has been defined as any answer other than "Definitely not" to all four questions (Nodora et al., 2014; Pierce et al., 1996). Since we used only one question to assess susceptibility our numbers for susceptible adolescents may be lower than if we had used the full adapted Pierce measure.

Our analyses are based on the 795 adolescent respondents in our sample who reported never using ENDS previously, a larger sample size would benefit external validity. Because our sample was not a random sample, there is potential for selection bias. There may have been unique characteristics among respondents that made them more likely to participate in our survey. Finally, as these were cross-sectional analyses, we are limited to association and are unable to infer causality. Future research in this field will benefit from using panel data to assess potential predictive effects of sleep deprivation on ENDS susceptibility and use over time.

5. Conclusion

We investigated the association between adolescent sleep deprivation and susceptibility to initiate ENDS use among adolescents who had never used ENDS previously. Compared to adolescents who reported averaging eight or more hours of sleep, adolescents who reported averaging less than six hours of sleep were at increased odds of reporting any likelihood of initiating ENDS use in the next month, even while considering relevant covariates. These findings are most important to researchers; however, identifying observable risk behaviors related to initiation of ENDS is beneficial to parents, mental health counselors, schools, and others directly engaged in promoting healthy adolescent behaviors and outcomes. These are interesting findings based on an approximately representative sample of adolescents aged 13 to 17 in the United States; however, the sample was not random and may suffer from selection bias. Similar analyses with a larger sample size is recommended and longitudinal analyses will better inform how variations in sleep durations relate to ENDS susceptibility and use over time.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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